

Internet of Things (IoT) Smart Plant Watering System: A Review

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Abstract-

This paper explores a Smart Plant Watering System built using Internet of Things (IoT) technology to automate plant irrigation. Water conservation and efficient irrigation are crucial in both agricultural and domestic environments. The proposed system utilizes a soil moisture sensor, microcontroller, and automated water pump to maintain optimal soil conditions. This method significantly reduces manual effort, prevents overwatering or underwatering, and improves water usage. The system is scalable, cost-effective, and adaptable for various applications ranging from urban gardening to rural farming. Testing results validate the system's potential to enhance irrigation management.

Keywords— IoT, smart irrigation, soil moisture sensor, automated farming, precision agriculture

1. INTRODUCTION

The exponential growth of the global population and urbanization demands efficient use of natural resources such as water. Agriculture, being one of the largest consumers of freshwater, requires innovation in irrigation techniques to address the challenges of water scarcity. Manual irrigation often leads to water wastage and inconsistencies in plant care. Recent advancements in IoT provide a foundation for building smart systems that can monitor environmental conditions and make intelligent decisions.

This research introduces a Smart Plant Watering System designed to automate irrigation using sensor feedback. By integrating soil moisture sensors, microcontrollers (ESP32 or Arduino), and relay modules to control a water pump, the system provides real-time water delivery precisely when required. This

paper discusses the design, architecture, implementation, and benefits of the proposed system.

2. SMART PLANT WATERING SYSTEM

The Smart Plant Watering System consists of several hardware components configured to perform automated irrigation. The key components include:

- Soil Moisture Sensor: Detects soil moisture levels in real time
- ESP32/Arduino: Acts as the brain of the system, processing sensor input and controlling output
- Relay Module: Interfaces between microcontroller and water pump
- Water Pump: Delivers water to the plant when triggered
- Power Source: Typically 12V DC supply or battery backup
- Optional Wi-Fi/Bluetooth Module: Enables cloud data monitoring and remote access

When the soil is dry (e.g., below 30% moisture), the sensor sends a signal to the microcontroller, which then activates the relay to switch on the pump. Once the soil reaches the desired moisture level, the pump is automatically turned off.

3. CHACATERISTICS OF SMART PLANT WATERING SYSTEM

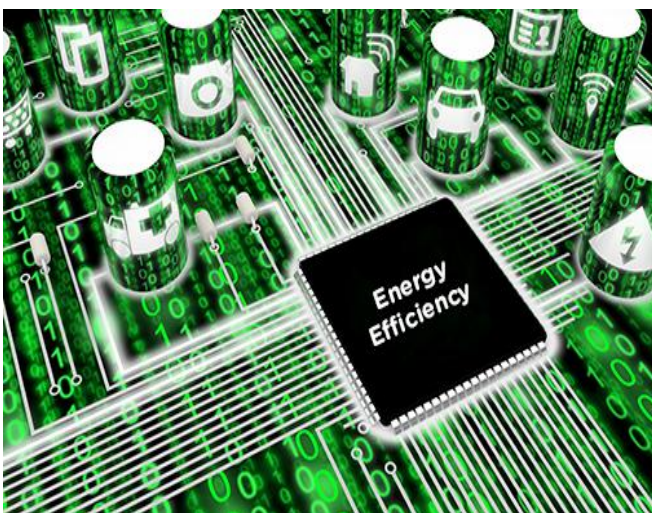
The Smart Watering System offers multiple features that distinguish it from traditional irrigation methods:

- 1) Automation: Eliminates the need for manual watering by relying on sensor data.
- 2) Efficiency: Reduces unnecessary water usage by irrigating only when needed.

- 3) Scalability: Can be expanded to multiple zones or plants using multiple sensors.
- 4) Remote Access: Data can be visualized via mobile apps or cloud platforms.
- 5) Low Maintenance: Simple, robust hardware minimizes the need for ongoing maintenance.
- 6) Cost-Effective: Uses readily available components and open-source platforms for affordability.

1) Automation

The core feature of the system is its ability to operate without human intervention. It continuously monitors soil moisture through sensors and makes real-time decisions to trigger or stop irrigation. This automation ensures consistent plant care regardless of the user's availability, improving plant health and reducing dependency on routine human observation.



2) Efficiency

Water is applied only when the sensor data indicates the soil is dry, eliminating overwatering and under-watering. This targeted irrigation reduces wastage

significantly and ensures plants receive the optimum amount of water based on actual conditions rather than a fixed schedule.

3) Scalability

The system is modular and can be expanded easily. Multiple sensors and control units can be installed to manage large-scale applications such as agricultural fields or multi-zone gardens. Each unit can be programmed individually or controlled centrally via a microcontroller, offering flexible deployment options.



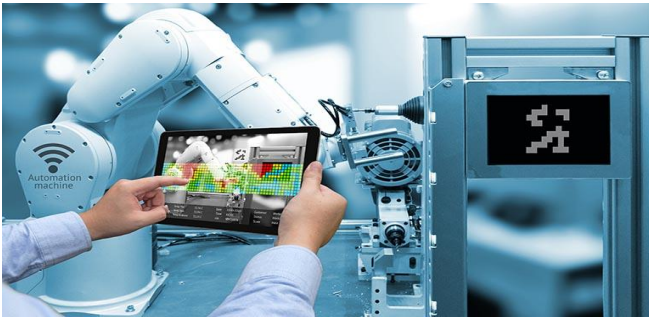
4) Remote-Access

By integrating Wi-Fi or GSM modules, users can monitor soil conditions and system status through cloud platforms or mobile apps like Blynk or ThingSpeak. This allows remote control of irrigation, real-time alerts, and data logging—even when the user is away from the physical site.



5) Low-Maintenance

Designed with simplicity in mind, the hardware (e.g., moisture sensors, relays, and microcontrollers) is reliable and has minimal mechanical wear. Routine maintenance includes cleaning sensor tips and checking pump functionality, which can be performed quickly without specialized knowledge.



6) Cost-Effective

The entire system can be assembled using low-cost, widely available components such as Arduino/ESP32, soil moisture sensors, and relay modules. It relies on open-source software and platforms, avoiding licensing costs. This makes the system accessible for hobbyists, students, farmers, and even large-scale agricultural operations in developing regions.



4. APPLICATION OF SMART PLANT WATERING SYSTEM

The system is designed to serve a variety of real-world scenarios including:

- 1) Home Gardening: Ideal for indoor and outdoor potted plants.
- 2) Greenhouses: Automates controlled environments to maintain optimal conditions.
- 3) Farms and Fields: Scalable version can manage irrigation for crops.
- 4) Public Parks: Reduces water wastage and manual effort in maintaining public green spaces.
- 5) Smart Cities: Integrates with urban environmental monitoring systems.

1) Home-Gardening

The system is especially beneficial for urban dwellers who grow plants on balconies, rooftops, or in backyard gardens. It eliminates the worry of forgetting to water plants, especially during vacations or busy workdays. Smart irrigation ensures optimal watering even in small spaces, improving plant health and reducing water bills.



2) Greenhouses

Greenhouses require tightly controlled humidity and moisture levels to ensure optimal plant growth. The smart watering system can be programmed to maintain precise soil moisture thresholds. By automating irrigation inside greenhouses, the system reduces the need for manual labor and ensures consistency in microclimatic conditions, leading to healthier and more productive crops.



3) Farms and Agricultural Fields

For medium to large-scale farming, the system can be deployed with multiple sensor nodes and centralized or decentralized control units. It allows for precision agriculture, where different sections of a field are irrigated based on local moisture levels. This reduces overall water usage, boosts crop yields, and supports sustainable farming practices.



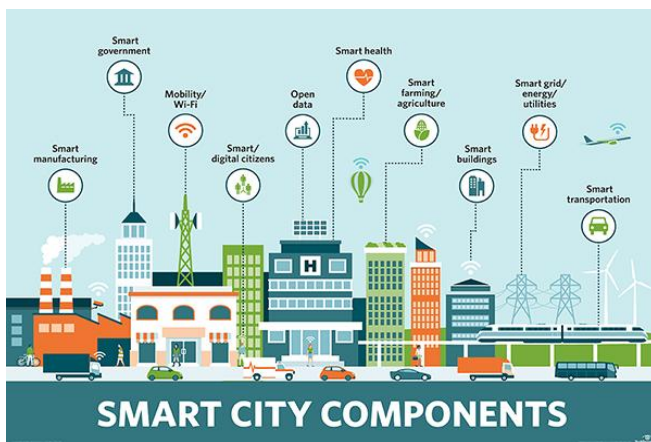
4) Public Parks and Urban Landscapes

Municipalities and city councils can use the system to automate irrigation in public green spaces such as parks, road medians, and botanical gardens. Timed or sensor-based irrigation prevents overwatering and ensures plants are well-maintained with minimal human effort, leading to cost savings in urban landscape maintenance.



5) Smart-Cities

As part of larger smart city infrastructure, the system can be integrated with weather stations and other environmental monitoring systems to optimize city-wide water consumption. Data analytics from cloud-connected watering systems can inform water conservation policies, detect irrigation anomalies, and reduce the city's overall water footprint.



5. CHALLENGE OF SMART PLANT WATERING SYSTEM

Despite its advantages, the Smart Watering System faces several challenges:

- 1) Sensor Accuracy: Sensor calibration can vary with soil type and environmental conditions.
- 2) Connectivity Issues: Limited or unstable internet connectivity in rural areas affects remote monitoring.
- 3) Power Supply Dependence: Continuous power is required; solar options are under exploration.
- 4) Hardware Wear and Tear: Pumps and relays may degrade over time requiring replacements.
- 5) Data Privacy: Cloud-enabled versions must safeguard transmitted data from breaches.

1) Sensor-Accuracy

Soil moisture sensors are influenced by the type and texture of soil (e.g., clay, sand, loam), as well as environmental factors like temperature and salinity. Calibration is essential for accurate readings but may require frequent adjustment depending on soil conditions. Low-cost sensors, while affordable, tend to degrade over time or lose accuracy, leading to inefficient watering if not periodically verified.

2) Connectivity-Issues

Reliable internet access is critical for systems with cloud or remote monitoring features. In rural or remote agricultural areas, Wi-Fi or cellular coverage may be limited or inconsistent. This can disrupt data logging, notifications, or remote control functionality. In such cases, the system may require offline operation modes or the integration of local data storage.

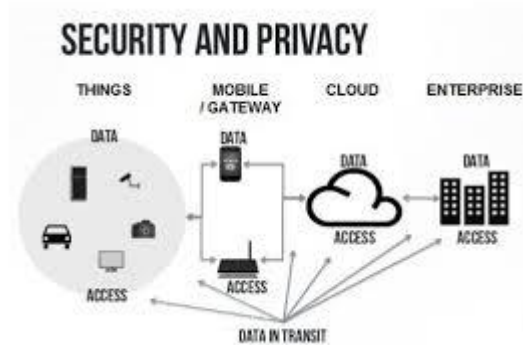


3) Power-Supply-Dependence

The system relies on a stable power source for its sensors, microcontroller, and water pump. In areas without reliable electricity, the system may become inoperative. Exploring alternative power solutions such as solar panels with battery backup can mitigate this issue but also increases initial cost and system complexity.

4) Hardware-Wear and Tear
Mechanical components like pumps, valves, and relays are subject to physical wear and environmental stress. For example, mineral buildup from hard water can clog pipes or damage pumps. Regular maintenance and component replacement are necessary to ensure long-term performance, especially in outdoor or high-use scenarios.

5) Data Privacy and Security
IoT systems often transmit data over the internet, which introduces potential vulnerabilities. If not secured, the system could be accessed or manipulated by unauthorized users. Cloud-based solutions must implement encryption, secure authentication, and regular firmware updates to protect user data and system integrity from cyber threats.



6. CONCLUSION OF SMART PLANT WATERING SYSTEM

The proposed Smart Plant Watering System effectively combines automation and environmental sensing to address the challenges of water management in plant care. Its low cost and modular design make it a viable solution for diverse users including farmers, researchers, and urban gardeners. This system ensures that plants receive the correct amount of water at the right time, thereby enhancing growth, conserving water, and reducing human effort. Future improvements may include solar energy integration, AI-based weather forecasting, and mobile app control.

7.ETHICS

This work is original and conducted with academic integrity. No part of the content has been plagiarized or submitted elsewhere. All hardware and software used in the system are open-source or legally sourced. Any external references are cited appropriately.

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